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Mapping Available Water for Developing Shale Plays

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Clean Water Matters: Challenges and Research Perspectives
Peking University
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U.S. DEPARTMENT OF ENERGY | NNSA

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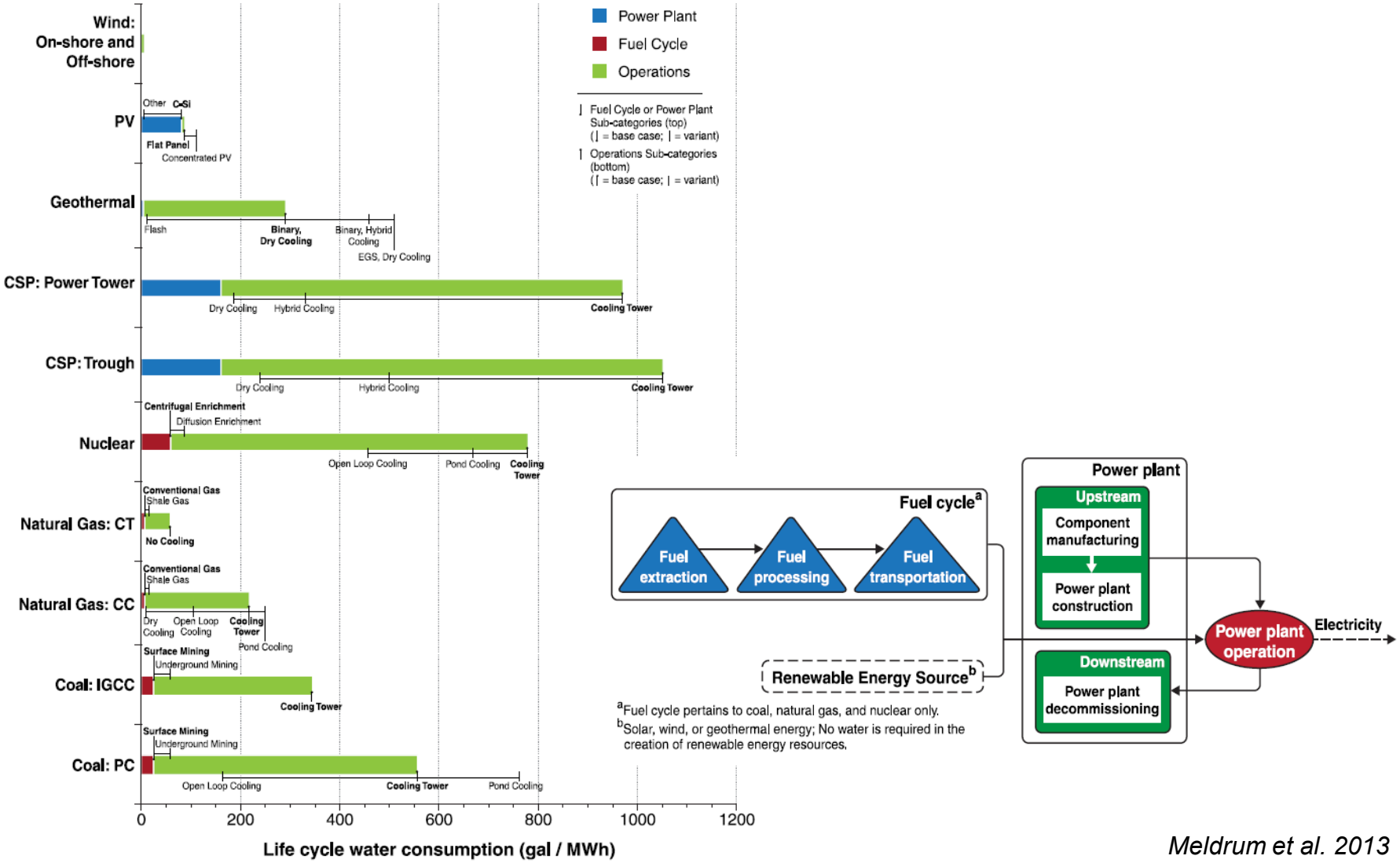
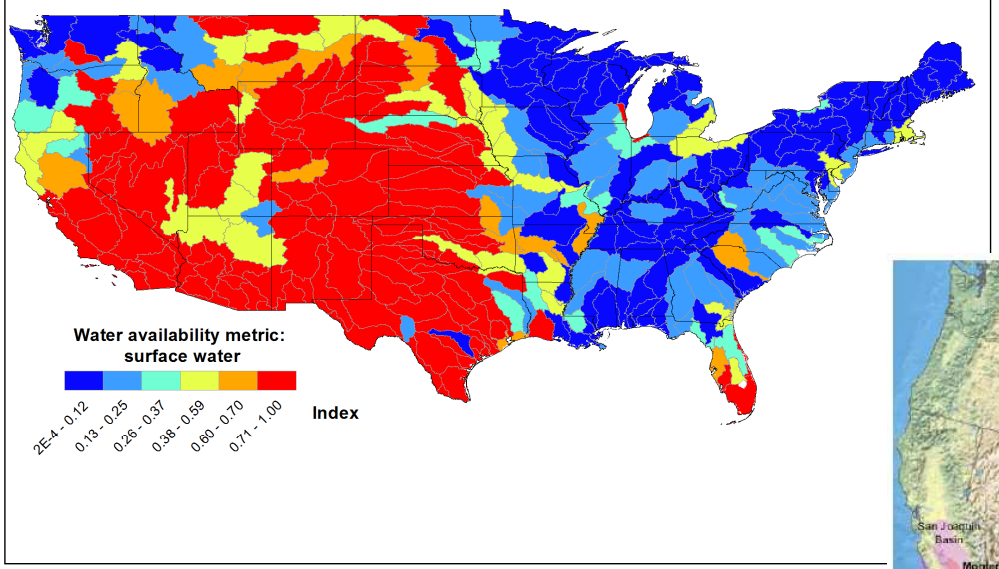
Context: Life Cycle Water Use



Meldrum et al. 2013

Potential Limits of Water on Shale Development

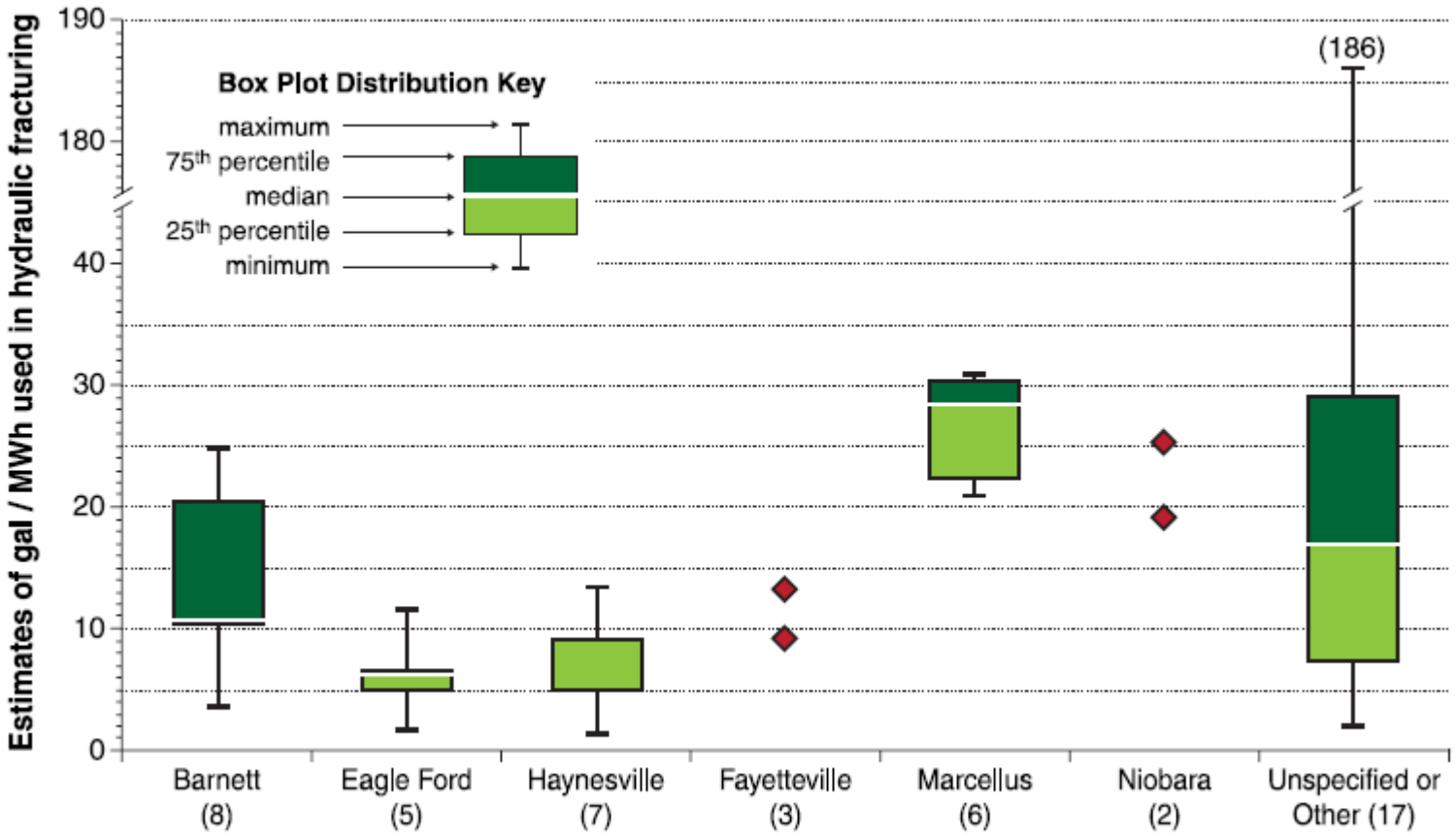
Gauged Streamflow vs. Consumption



Shale Plays in U.S.

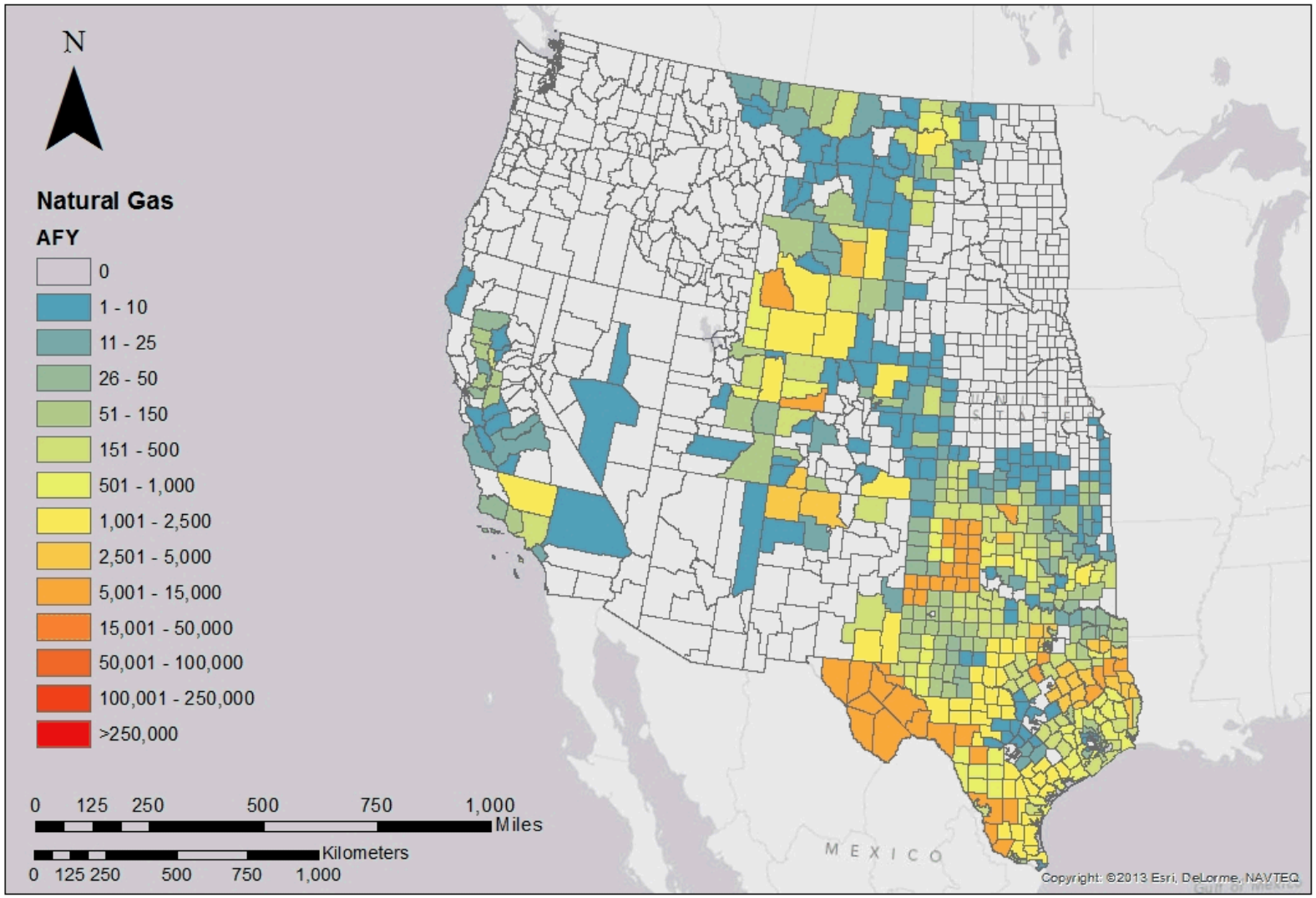
Water Use in Hydraulic Fracturing

7,500 to 20,000 m^3 of Water to Hydraulically Fracture a Well



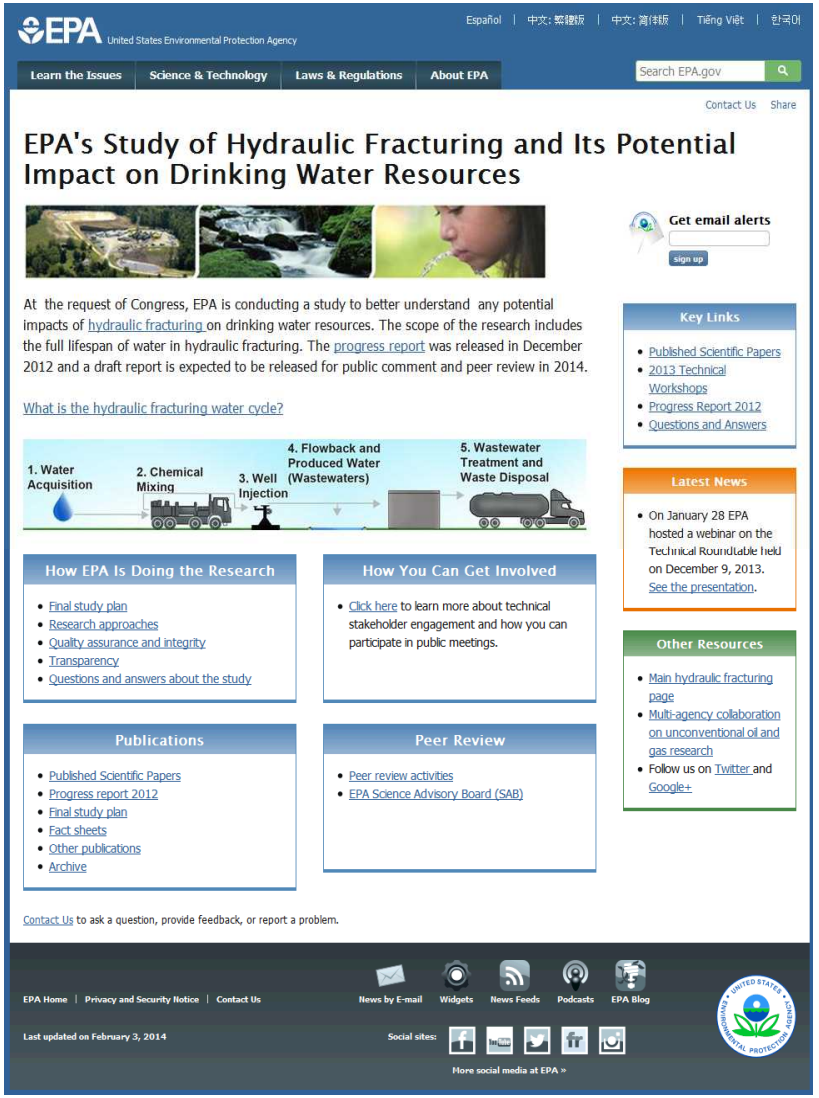
Meldrum et al. 2013

Water for Natural Gas Extraction



Reducing Water Impacts

- Re-use of produced water
- Use of brackish water
- Protection of fresh water resources



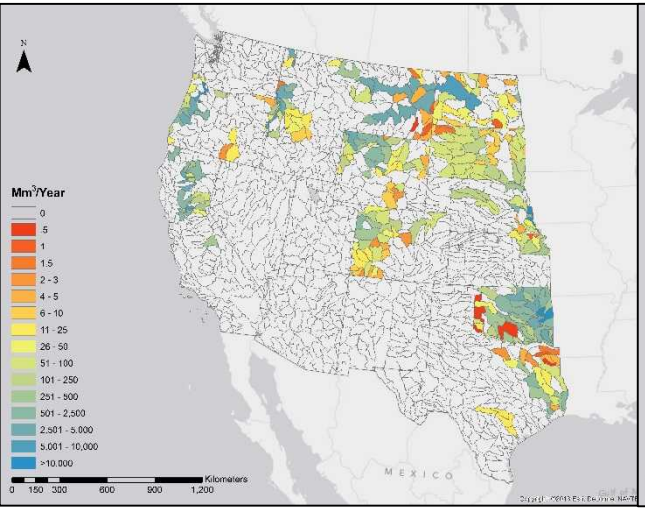
Weighting Different Water Options

- **Potable Water**
  - **Unappropriated surface water**
  - **Appropriated surface water (rights transfers)**
  - **Groundwater**
- **Non-Potable Water**
  - **Municipal/Industrial wastewater**
  - **Shallow brackish water**

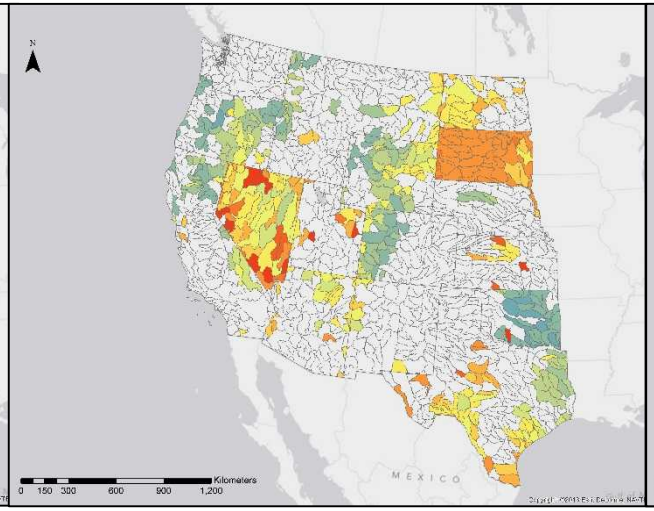
Relative Availability and Cost

Water Availability

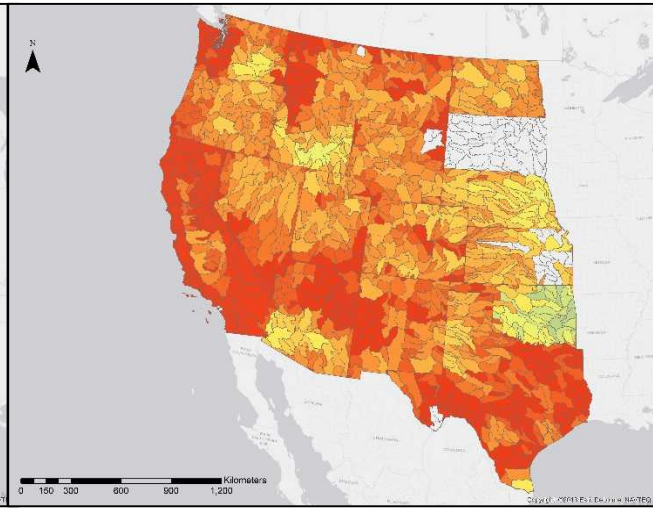
Unappropriated Surface Water



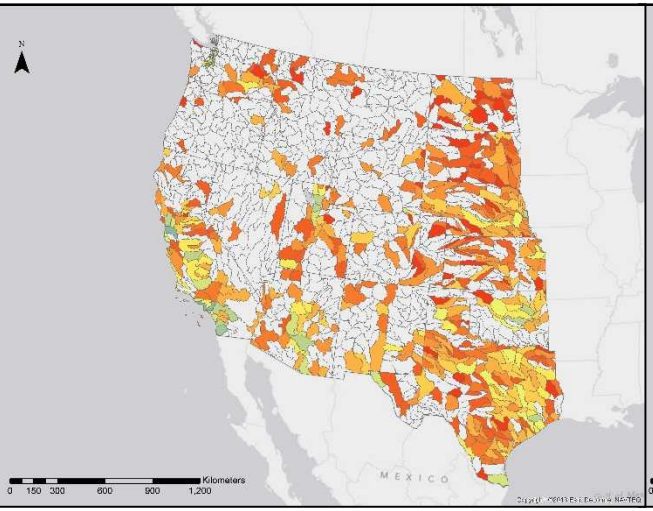
Unappropriated Groundwater



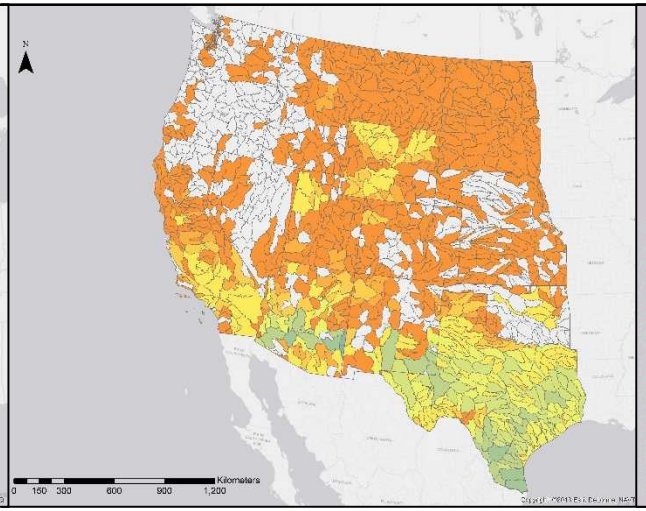
Appropriated Water



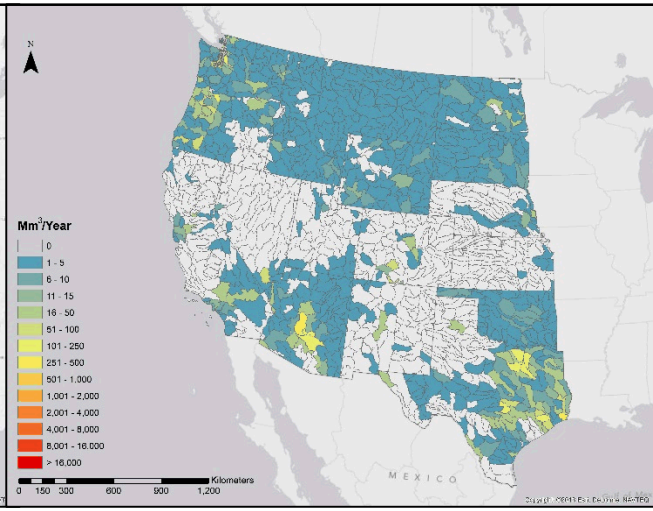
Municipal Wastewater



Brackish Groundwater

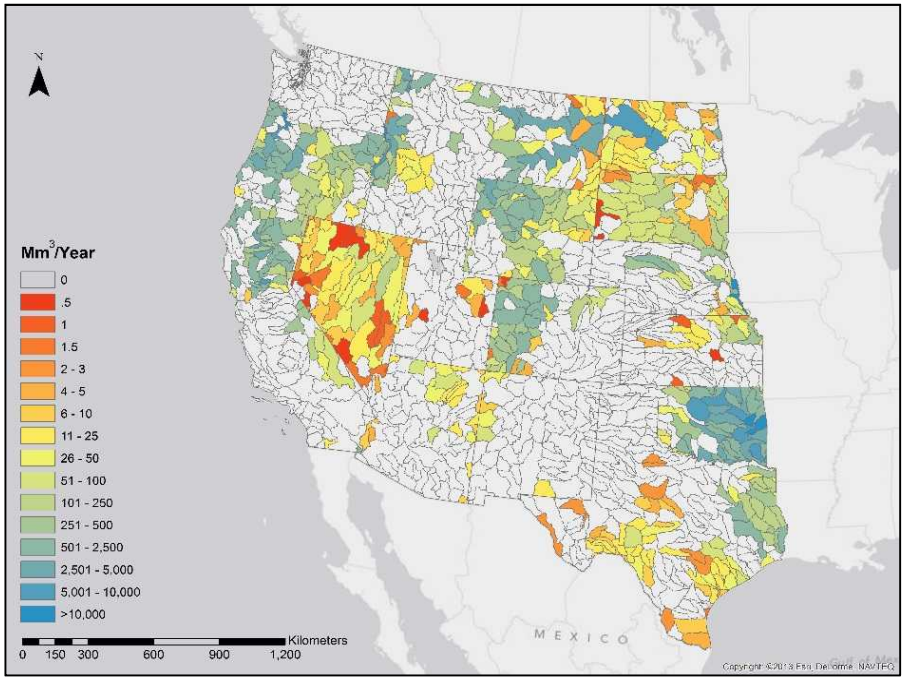


Consumptive Demand 2010-2030

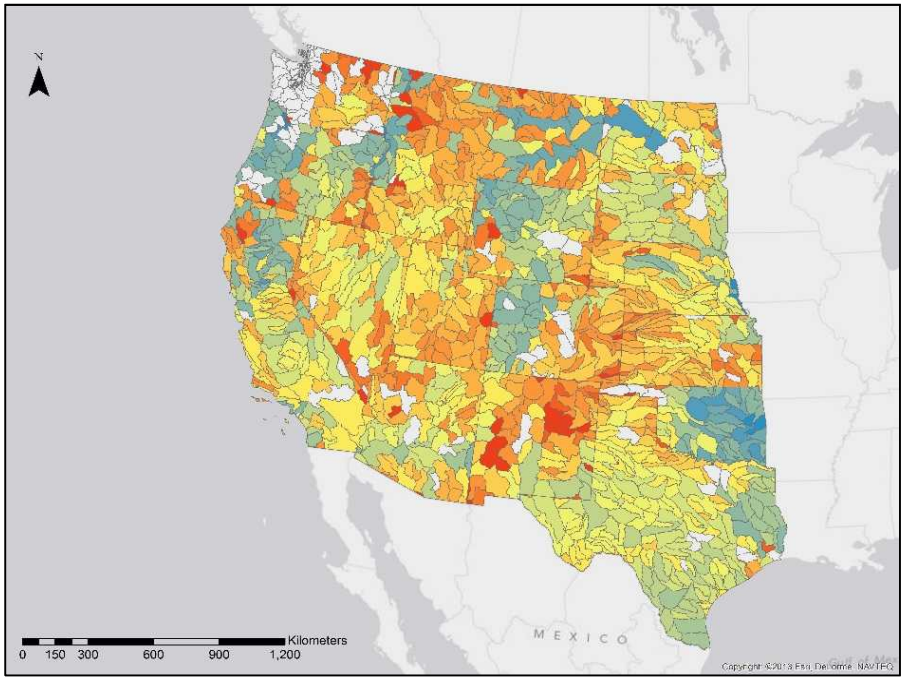


Water for Development

Unappropriated Sources – New Demand

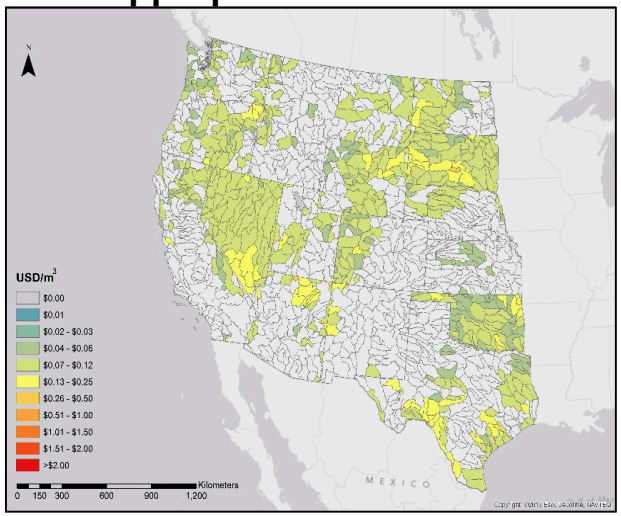


All Sources – New Demand

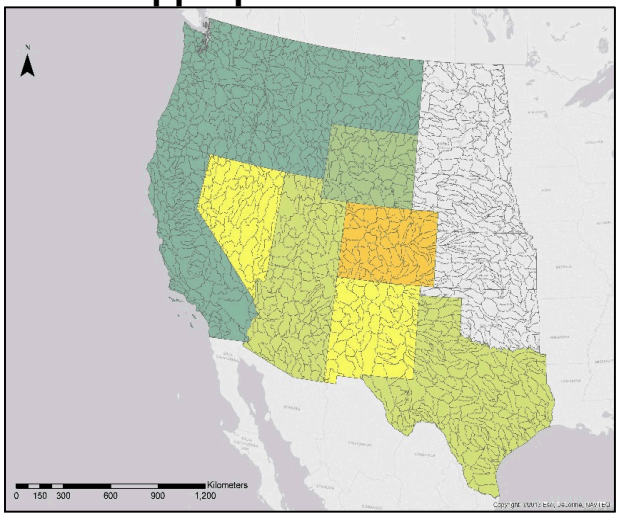


Relative Cost of Water

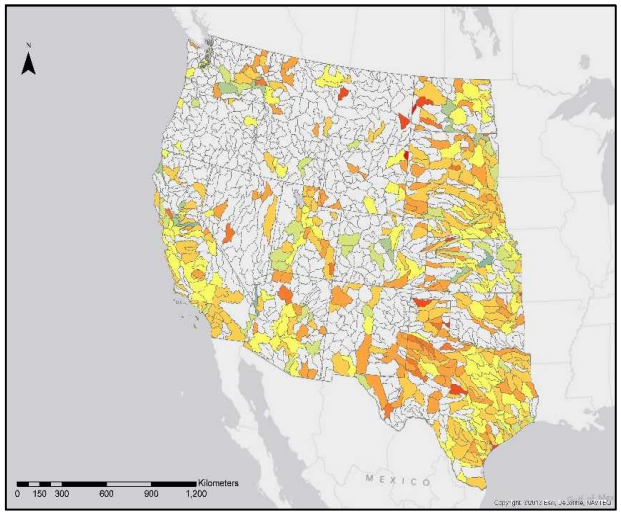
Unappropriated Groundwater



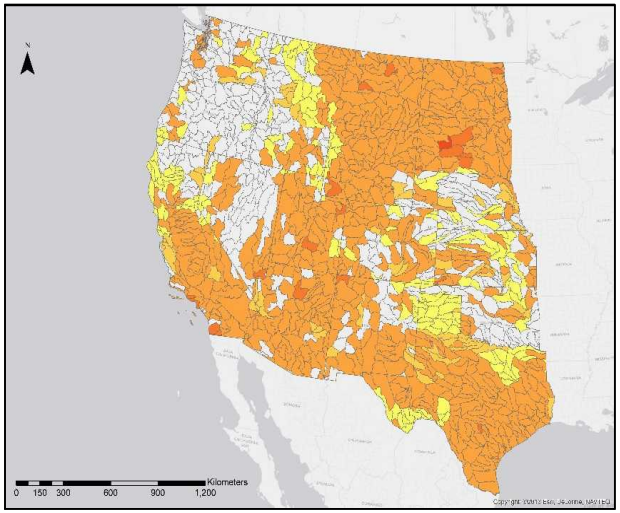
Appropriated Water



Municipal Wastewater



Brackish Groundwater



Environmental Risk Metric

Risk Calculation Methodology

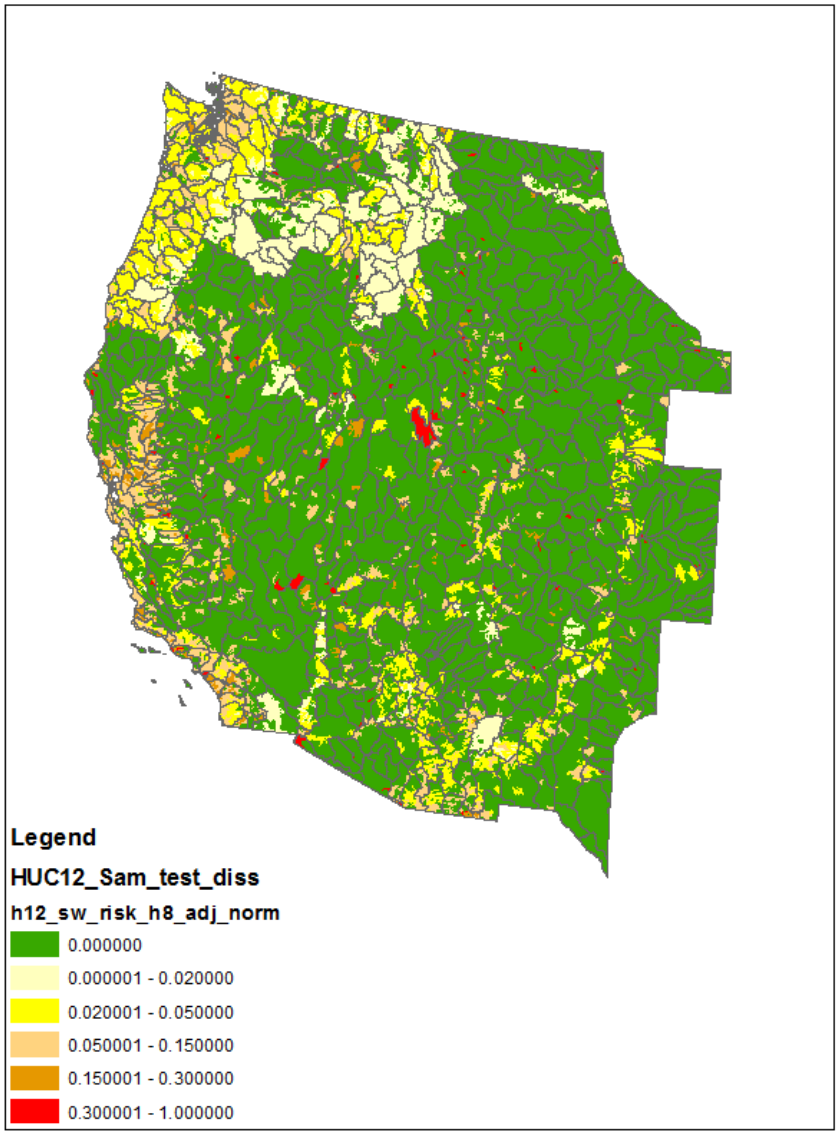
- Only species utilizing aquatic and riparian habitats are considered
- **Overall Risk** to a region from Water Extraction **(OR) = IR + AR** Eq1
- **Individual Risk (IR)** to a region is product of 4 Species Vulnerability Categories (**sij**'s) and 3 Habitat Vulnerability Categories (**hik**'s)
- **IR = ∑[(sij1 + sij2 + sij3 + sij4 + CF) * (hik1 + hik2 + hik3sw/gw) * EE]** Eq2

  sij1 = Diversity
  sij2 = Imperilment
  sij3 = Endemicity
  sij4 = Sensitivity

  hik1 = Area
  hik2 = Critical habitat
  hik3 = Habitat type
  hik3 risks are separate for surface- (sw) and groundwater (gw)

- Edge-effect filter **EE_8 factors (0.5, 1) and EE_{12} factors (1, 2)**
- **Association Risk (AR) = 0.5 * IR** of Immediate Downstream Polygon Eq3
- Correction Factor (CF - Binary), Edge-effect (EE) filter, and Association Risk (AR) – Not used for this analysis

HUC-12 Risk Map (From Surface Withdrawals)



Summary

- Location matters
- Data is required to weigh water supply options:
  - Availability,
  - Competing demands,
  - Cost, and
  - Environmental concerns